Instrument Incubator

Wideband Autocorrelation Radiometer Receiver Development and Demonstration for Direct Measurement of Terrestrial Snow and Ice Accumulation

Completed Technology Project (2017 - 2018)

Project Introduction

The seasonal terrestrial snow pack is an important source of water for many parts of the globe. Snow's high albedo, relative to the terrain in the absence of snow, is an important driver of Earth's energy balance, and long term changes to the statistics of the snow pack's properties are both a consequence and a cause of climate change. The global quantification of the amount of water in the snow pack reservoir is a long term objective of NASA's Earth Science Division. Thus far, the primary means of quantifying the amount of snow on the ground has been via the differential scatter-darkening mechanism, such as the 19 and 37 GHz brightness difference. While a 35+ year time series of passive microwave satellite data has been made, progress in understanding the scatter-darkened brightness signature of snow continues, especially for forested areas where vegetation scattering confounds the signature. This proposal looks to advance an alternative approach to using passive microwave to measure the snow accumulation. Wideband autocorrelation radiometry (WiBAR) is a technique wherein the electromagnetic propagation time across a layered media, such as snow pack or lake ice, can be remotely sensed. Thermal emission from the ground under the snow pack propagates up through the snow pack to the receiver. When the upper and lower surfaces of the snow pack are locally smooth, which is true at sufficiently long wavelengths, additional paths result from the reflection of the upward traveling wave from first the upper and then the lower surface of the snow pack. Arriving at the antenna, these waves are identical except for their amplitude and the time lag associated with the extra transit of the snow pack. This time lag is the observable. For sufficiently long wavelengths, the snow snow grains that cause the scattering are sufficiently deep in the Rayleigh region so as to be of minor importance. Unlike scatter darkening, where the microscopic properties of snow dominate the signal and the desired macroscopic properties are secondary, for WiBAR, the macroscopic properties of the snow depth is the most important parameter determining the signal, modified by the density (and thus it measures SWE), and the microscopic properties, responsible for the scattering, reduce the signal strength but do not alter the quantification of the accumulation. The bandwidth of the radiometer determines the minimum vertical extent that is observable. A wide bandwidth (several gigahertz) is desired for the relatively shallow snow covers encountered on Earth. We have demonstrated that this signal exists and can be observed both for a snow pack and for a fresh-water lake ice pack with ground-based observations. We have done this with a spectrum analyzer functioning as the radiometer receiver back-end: in the frequency domain, the delayed ray interferes with the direct ray to produce constructive maxima and destructive minima in the brightness spectra. But this technique is inherently slow, as the number of samples required is high and the instantaneous bandwidth is low. This frequency-domain approach is much too slow for spaceborne or even airborne observation. These observations also confirm the robustness of the approach to radio-frequency interference (RFI): since the

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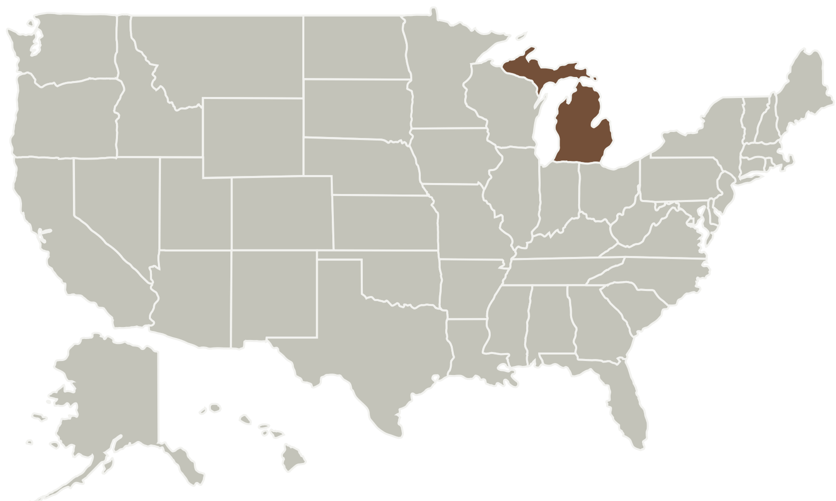
observable is a time-delay and not a brightness magnitude, the narrow-band RFI does not mask the broadband WiBAR signature. We propose to develop a radiometer back-end that observes the entire spectrum of interest simultaneously, which will greatly reduce the observation time, possibly down to the order of milliseconds, which would make observations from a moving platform possible. We will then demonstrate the technological advancement in a direct comparison to the spectrum analyzer-based receiver measurement in a laboratory setting.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Michigan-Ann Arbor	Lead Organization	Academia	Ann Arbor, Michigan

Primary U.S. Work Locations
Michigan

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

University of Michigan-Ann Arbor

Responsible Program:

Instrument Incubator

Project Management

Program Director:

Pamela S Millar

Program Manager:

Parminder S Ghuman

Principal Investigator:

Roger De Roo

Co-Investigators:

Linda Brooks
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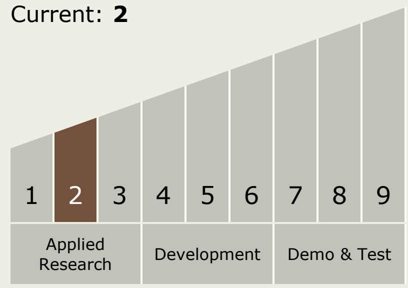
Technology Maturity (TRL)

Start: **2**
Current: **2**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.1 Remote Sensing Instruments/Sensors
    └ TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

Target Destination

Earth